THE WEATHER AND CIRCULATION OF MARCH 1954 [1]

A COOL MARCH WITH A 6-DAY PERIODICITY

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The weather during the first month of spring 1954 displayed quite a few noteworthy features. These included: a marked temperature reversal, i. e., a cool March following the warmest February of record in the United States [1]; a recurrence of Pacific blocking very similar to that of January 1954 [2]; further intensification of the Southwestern drought; and manifestation of another spring periodicity in the United States.

THE TEMPERATURE REVERSAL—FEBRUARY TO MARCH

Despite the well-known vagaries of March weather, one of the outstanding aspects of the weather this month was the widespread prevalence of below normal temperatures (Chart I–B) succeeding the warmest February in 62 years of record. While such February to March changes are not unknown, the more favored months for reversals are October to November and, less frequently, April to May. In studies of recent monthly anomaly patterns of temperature, precipitation, and height, Namias [3, 4] has shown that there has been some tendency for February–March regimes to persist, i. e., to resemble each other, rather than the contrary.

More interesting, perhaps, than this immediate aspect of low persistence is the addition of another cool March to the curious repetitions of cool March weather (in the United States) which have occurred in recent years. Weighted temperature averages for the United States show below normal temperatures during every March of the last 8 years except 1953 [5]. Moreover, this has also been true for 10 of the last 13 years (for March). Although these data seem rather impressive, a survey of the 62 years of record reveals that such runs are not too unusual. For instance, since 1893 the following March sequences were evidenced:

Below normal	10 out of 13 years (1912–24)
	9 out of 12 years (1943–54)
Above normal	8 out of 10 years (1902–11)
	7 out of 8 years (1933–40)

These data may provide a little more evidence to those seeking long-term periodic fluctuations in weather. Inspection of the outstanding sequences obviously suggests a possible oscillation with a period of the order of 30 years. This may be related to the historic Brückner cycle [6] (35 years), but the substantiation of any such connection is beyond the scope of this article.

GENERAL CIRCULATION CHARACTERISTICS

The cool temperatures of March were not unusual when examined in terms of the prevailing circulation pattern. Figure 1 shows the mean 700-mb. heights and their departures from normal for March. These points seem relevent: (1) Heights were below normal over just about all of the United States. (2) Heights were significantly above normal (maximum of 390 ft.) in the northeastern Pacific. (3) The polar vortex (80° N., 130° E.) was relatively strong (350 feet below normal) but well removed from North America.

These conditions were quite opposite to those which prevailed in February. The stronger-than-normal westerlies which then maintained over the eastern Pacific and North America were replaced by weaker-than-normal westerlies in March. Furthermore, rising heights in the northeast Pacific and Canada were accompanied at sea level by a marked decrease of cyclonic activity in the Gulf of Alaska (Chart XI), and a marked increase in the intensity of the polar anticyclone over western Canada. The latter can also be associated with the weakening and retreat of the polar vortex. These same changes were associated with sea-level departures from normal of +14 mb. in the Gulf of Alaska and +5 mb. over Saskatchewan (Chart XI inset).

The increased importance of polar anticyclones is shown by the tracks (Chart IX) of repeated thrusts of cold air from Canada into the United States. Their effect upon the temperature regime (illustrated in Chart I–B) was to produce temperatures some 6° F. below normal in Montana, with below normal anomalies extending southeastward through Florida. In the Far West temperatures were below normal mainly as a result of cold unstable maritime air associated with a deeper than normal trough in California. In small areas of the Southwest and Northeast, temperatures were above normal but only slightly so.

At upper levels, the essential characteristics of the atmospheric flow pattern were much the same as at the

[1] See Charts I–XV following p. 95 for analyzed climatological data for the month.

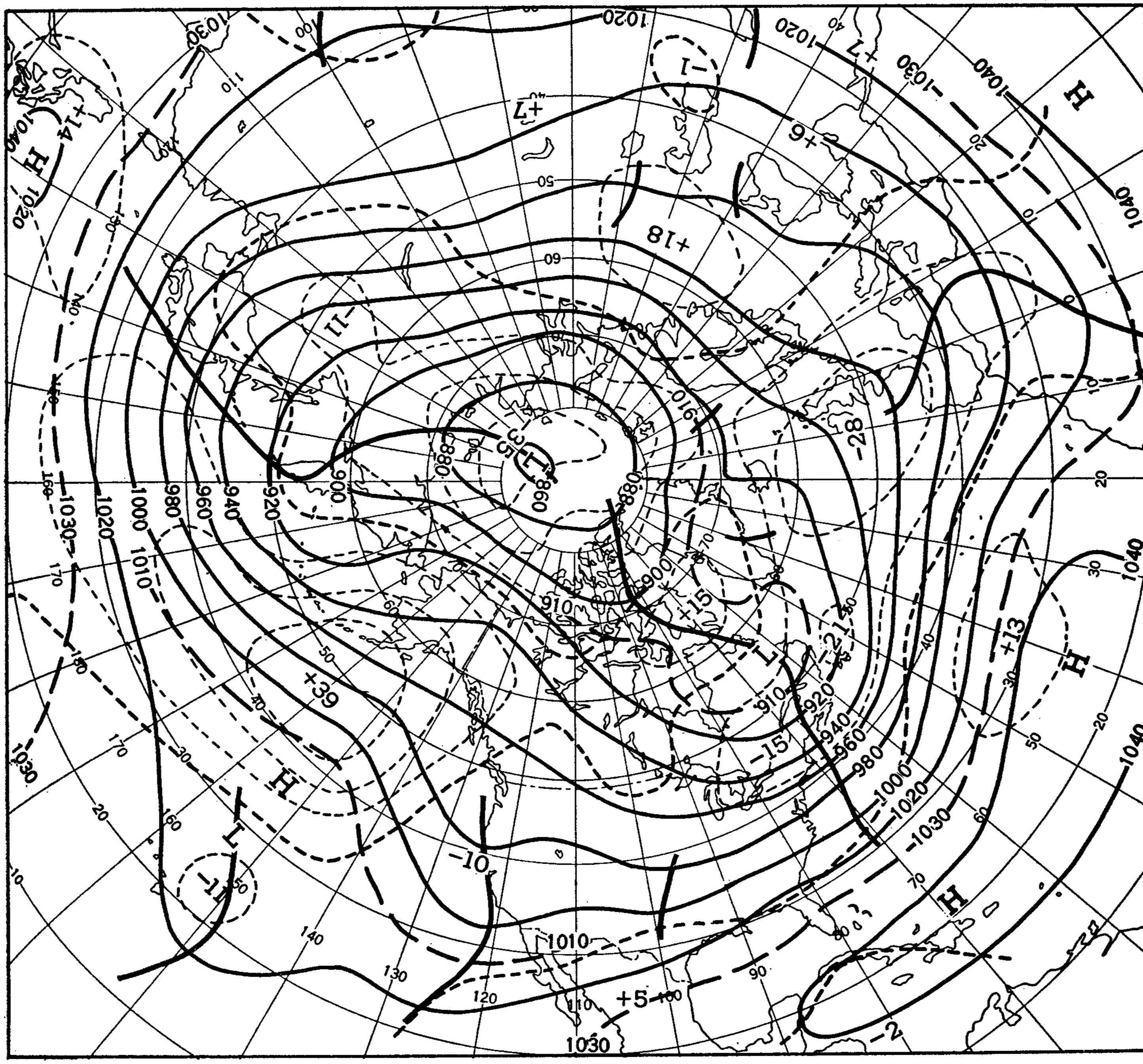


FIGURE 1.—Mean 700-mb. contours and height departures from normal (both in tens of feet) for the 30-day period March 2–31, 1954. Note abnormal ridge (heights 390 ft. above normal) in the northeast Pacific, weaker than normal midlatitude westerlies from mid-Pacific to mid-North America, and broad zone of confluence over central United States.

surface. The eastern Asiatic coastal trough existed up through the 200-mb. level (fig. 2) and was accompanied by geostrophic wind speeds averaging 60 to 70 m./sec. around 30° N. The occurrence of strong jets in the southern Japanese Islands is quite common, but monthly averages for March are not usually so high. This wind maximum (solid arrows in fig. 2) had at lower latitudes a clearly defined trajectory from Japan through the Hawaiian Islands to the southern United States, then out across the Atlantic and through northern Africa. To the north of this circumpolar whirl the mean troughs and ridges were superimposed upon a slower westerly flow. These features can be readily associated with their 700-mb. counterparts.

The implication appears to be that there was little or nothing abnormal about the interrelation of trough-ridge features within the troposphere. Rather, that the determining factor in the cool regime of March was the orientation and intensity of the troughs and ridges. In this connection it may be pertinent to point out that fairly important transitions occurred within March.

During the first half of March, heights rose in the temperate latitudes of the mid-Pacific. Figure 3a shows this strong mean ridge and the two-trough Pacific pattern

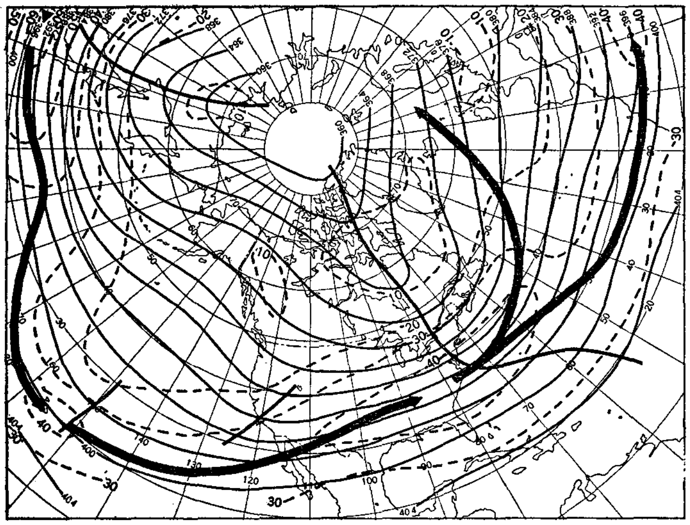


FIGURE 2.—Mean 200-mb. contours (in hundreds of feet) and geostrophic wind speeds (m./sec.) for the 30-day period March 2–31, 1954. A strong belt of lower-latitude westerly winds encircled a weaker westerly flow to the north in which the "sinusoidal" perturbations were embedded.

which accompanied it. This was a marked change from the strong cyclonic sweep at middle latitudes which dominated the whole ocean in February. Other changes of note included the association of the polar vortex with the Asiatic coastal trough rather than the North American trough. Related to this was the development of closed Low conditions near James Bay. This regime ended the prolonged spell of warm weather over most of the United States and brought frost or freezing temperatures as far south as the Florida Everglades and measurable amounts of snow all the way to the Gulf Coast (4 inches in parts of Mobile, Ala). On March 5 Cleveland, Ohio, reported five straight days of snow and wind with a total snowfall of 20.8 inches.

During the latter half of the month, a strong ridge, which began to build before the 15th, developed in the Gulf of Alaska (fig. 3b). The ridge was associated with a marked wave of blocking which retrograded very slowly across the eastern Pacific after a fairly rapid traverse of the blocking surge from the northeast Atlantic. The mean effect of this anomalous ridge (fig. 3b) was to produce northerly to northwesterly winds from the eastern Gulf of Alaska to Hudson Bay. Cold cP and mP air was swept southward into the north-central and northwestern United States in a broad confluence zone. Within this area repeated cyclogenesis gave rise to major storm developments which moved eastward as they deepened on the strong thermal contrast and were followed by cold air sweeps southward. (See tracks of cyclones and anticyclones, Charts IX and X.) The flat, fast, low latitude westerlies across the United States and Atlantic seem directly associated with this confluence pattern, and the former were a significant factor in the concomitant precipitation regime (Chart III).

A very similar blocking regime occurred in the Pacific during mid-January 1954 and has been described at length by Krueger [2]. For purposes of comparison, the mean

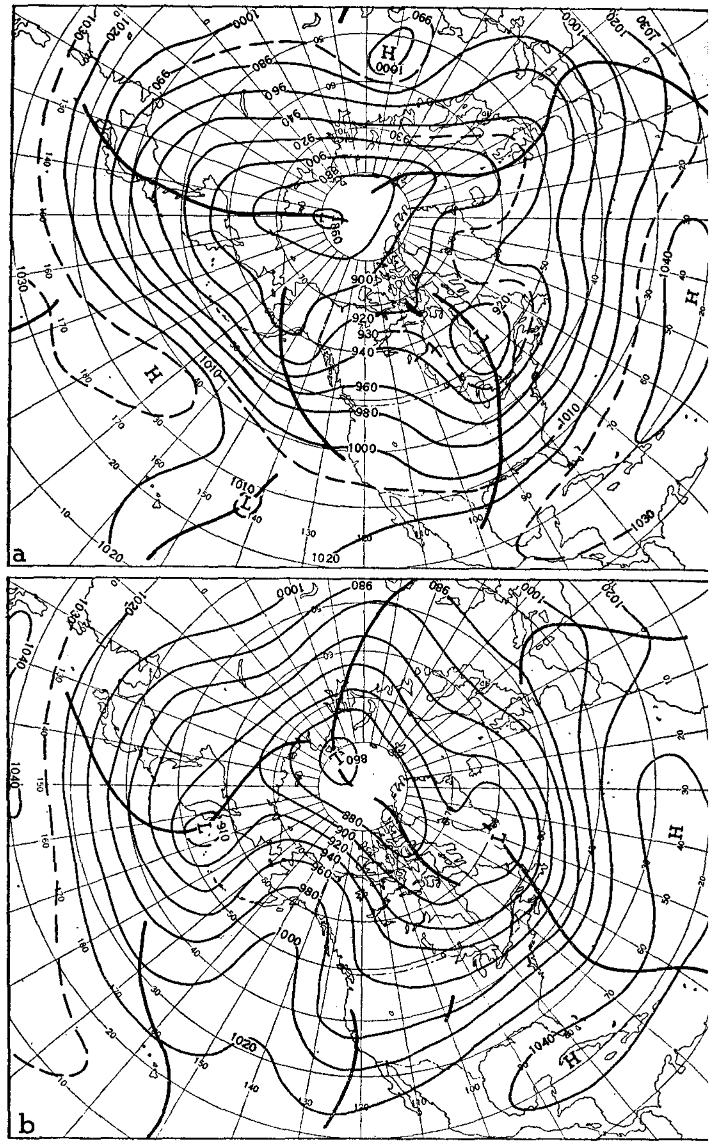


FIGURE 3.—(a) Fifteen-day mean 700-mb. heights for February 28–March 14, 1954. Strong subtropical ridge in central Pacific represented a marked change from the broad cyclonic sweep of February. Traces of blocking were evident in the North Atlantic. (b) Fifteen-day mean 700-mb. heights for March 17–31, 1954. Anticyclonic circulation dominated the northeast Pacific. Strong northwesterly flow over western Canada led to a broad zone of confluence over North America and marked intrusions of cold cP air into the United States.

heights for a 15-day mid-January period (9–23, inclusive) are shown in figure 4. The major characteristics of eastern Pacific ridge, west coast trough, and flat westerlies over the United States with a broad band of confluence over North America are notably similar. In general, the orientation, speed, and intensity of these transitions are strikingly alike.

SOUTHWESTERN DROUGHT

On March 1, 1954, the *Weekly Weather and Crop Bulletin* [7] reported "The moisture situation is critical in an area including extreme southwestern Nebraska, eastern sections of Colorado and New Mexico, and in western portions of Kansas, Oklahoma, and Texas, where frequent soil-drifting winds damaged small grains and pastures."

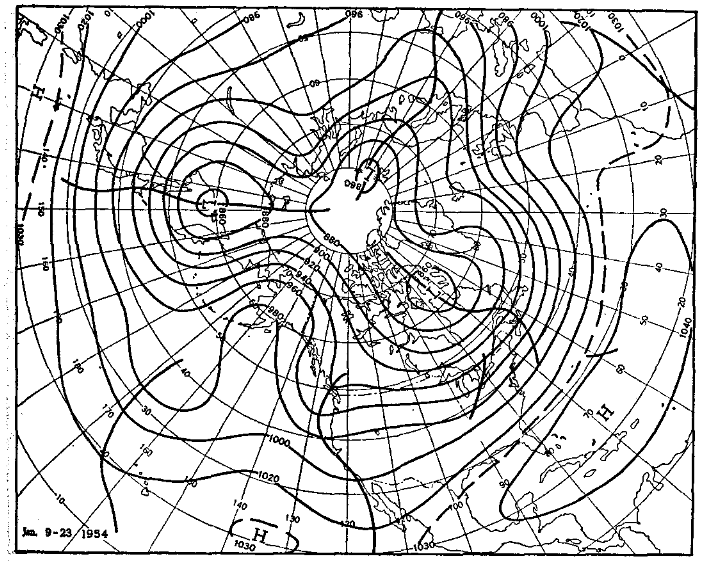


FIGURE 4.—Fifteen-day mean 700-mb. heights for January 9–23, 1954. Blocking in the eastern Pacific may be compared to that of latter half of March (fig. 3b). Speed of retrogression, intensity, and relation of even remote circulation features are quite similar.

During the first half of March this region was in the area of west-northwesterly flow with the mean trough located to its east in the Mississippi Valley (fig. 3a). Perturbations from the Pacific trough produced rain over the Far West and Northwest. Considerable amounts also occurred in and ahead of the Mississippi Valley trough. On the 10th and 11th (see fig. 5a for map of the 13th), a major cyclone spread considerable precipitation across the northern Plains. However, the major area of drought received no material alleviation.

In the latter half of the month (fig. 3b), fast westerlies at lower latitudes projected the rain shadow of the Rockies eastward over most of the drought area. Thus dry conditions prevailed in the generally confluent circulation pattern despite a broad mean trough in the western United States and cyclonic developments in the zone of cyclonic shear. Precipitation did affect all but southwestern Texas as these perturbations passed eastward. But no rains of consequence occurred in the outlined drought area due, in part at least, to the foehn desiccation of downslope westerly winds.

Much of this drought region had received less than 1.00 in. of precipitation in the last 4 months. Some localities were experiencing their worst drought on record, and Soil Conservation Officials placed the official title of "Dust Bowl" upon two areas, one in west Texas and New Mexico and the other in southeastern Colorado and southwestern Kansas. Total fields ruined by wind erosion extended over an area of some 12,000 square miles. Damage and crop losses were calculated in millions of dollars. Similarities to the winter-spring drought of 1903–04 were suggested. On that occasion, it is interesting to note, alleviation of the drought and initiation of a prolonged drought-free period occurred the following summer.

ANOTHER SPRING PERIODICITY

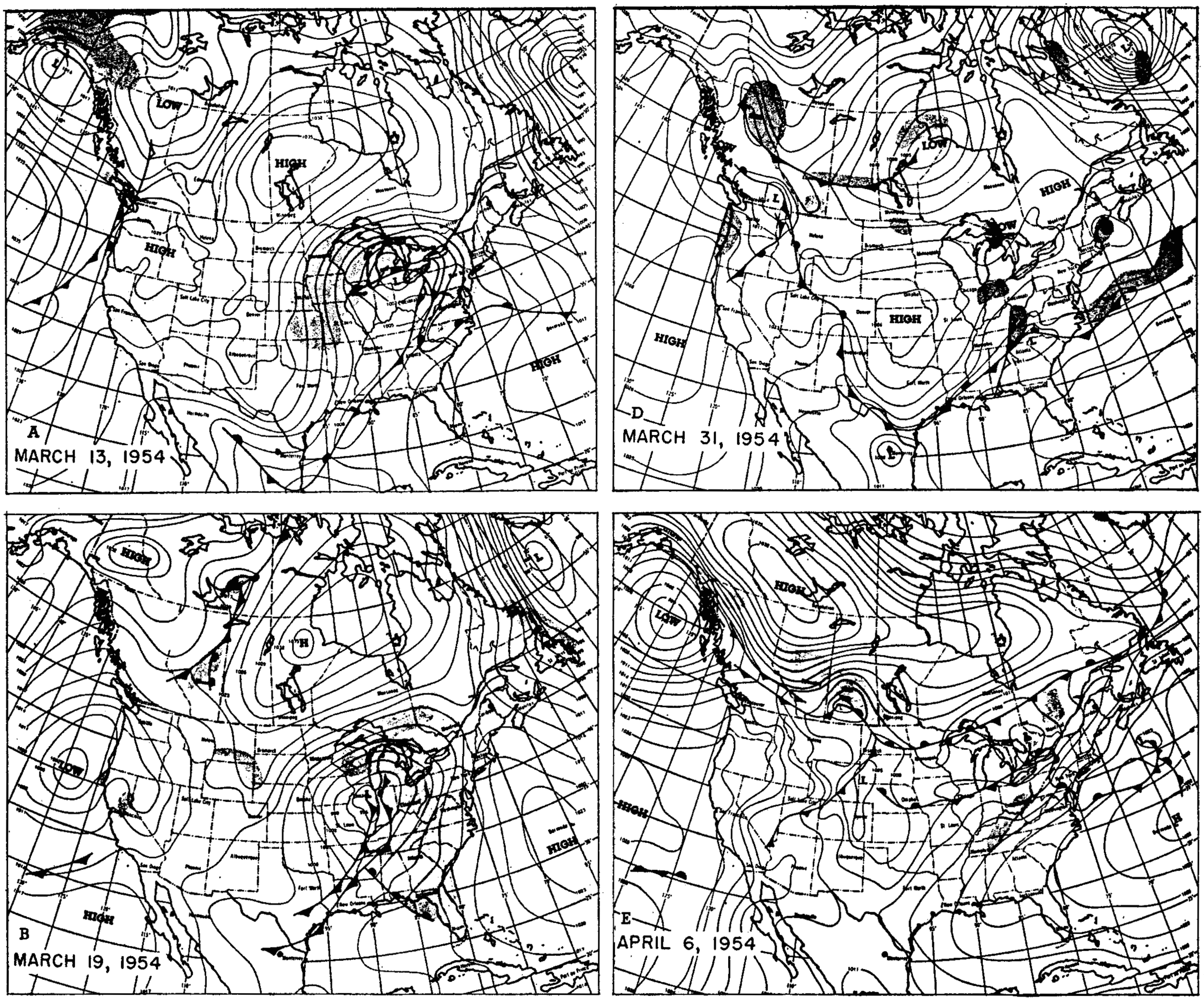
Periodic recurrences in the weather have been a feature of the recent spring seasons. As a result of the rainfall recurrences pointed out by Langmuir in connection with cloud-seeding evaluations [8], renewed interest in this aspect of weather changes has led to work by Brier [9], Hall [10], Hawkins [11], and more recently by Namias [12]. In view of the periodicities brought to light in this relatively short interval, it seems reasonable to assume that extensive investigation of carefully chosen locales, lengths of record, and time periods would reveal many more periodicities. Namias has emphasized the limitations of "statistical straitjackets" as adequate indicators of the validity and usefulness of recurrences. However, without some standard of measure, the evaluation of periodicities tends to become subjective with possibly but little agreement among the various evaluators.

A case in point was the weather over the United States for the period March 8 through April 6, 1954. By March 25, three major storm centers had emerged from the West and greatly affected the Great Lakes area. The storms were almost evenly spaced, about 6 days apart. Figures 5a, 5b, and 5c show the North American synoptic weather maps (1:30 p. m., EST) for March 13, 19, and 25,[2] published by the Weather Bureau. The similarities, especially evident when one considers timing, development, and history, were obvious to the synoptician. By the time this sequence had become apparent and its implications appreciated in a periodic sense, the major question was whether these recurrences could be expected to continue.

Figures 5d and 5e show the patterns for the 6th and 12th days following figure 5c. These are illustrative of a type of modification which frequently besets sequences. In this case the disturbances continued with fair regularity in the western United States. However, as these perturbations traveled downstream, they suffered considerable modification. It is evident that there were considerable differences in the size, intensity, latitude, etc., of the disturbances when compared to those of the 13th, 19th, and 25th. This is one of the forms of transition which subjective evaluations frequently cannot agree upon and which are hardly fitted to standard statistical procedures. Yet some traces of the 6-day period could be detected by the willing eye.

Nevertheless, the standard statistical tests [13] were applied to the 700-mb. data for the entire 30-day period in order to gain a purely objective evaluation. The tabulated values of the 1500 GMT heights at the 10-degree longitude intersections along 40° N. from 130° W. to 70° W. (from the data analyzed daily in the Extended Forecast Section) for the period March 8 to April 6 were used for this purpose. A cosine curve was fitted to the 30 discrete values at each point in such fashion as to minimize the square of the deviations of the curves from the

[2] See adjacent article by Allen and Creasi for analysis of this storm.



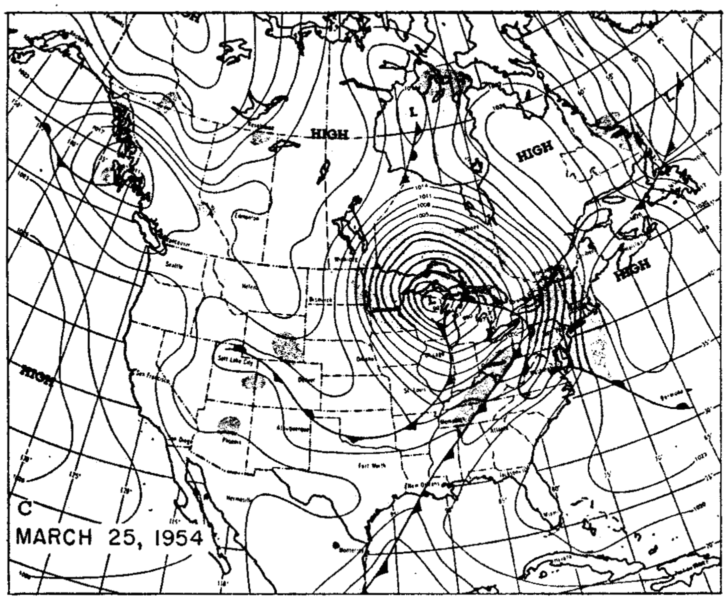


FIGURE 5.—Synoptic sea level maps 6 days apart. Note marked resemblance of disturbances in the Great Lakes region on (A), (B), and (C). These storms were major weather producers with similar histories and showed obvious periodicity. Maps in (D) and (E) show deterioration of the recurrence in the Great Lakes area, although traces of the periodicity seemed to persist.

observed values. The 6-day periodic element was then expressed

$$Y = A \cos \frac{360}{6} (x - \theta)$$

where Y = the height in feet (expressed as departure from the mean) for the day of the period designated by x.

A = the amplitude (½ the total swing) of the fitted curve in feet.

x varies from 0, 1, 2, . . . 5 corresponding to the day in the period.

θ = phase angle in units and tenths of days. Thus in the cosine function employed, the phase angle indicates the day in the period when Y (the height) would be at a maximum.

The results obtained are shown in table 1, where R is the correlation of the fitted curve with the appropriate daily height values for all of the 30 days.

TABLE 1.—*Amplitude, phase angle, and correlation of the 6-day periodic component in the 700-mb. heights along 40° N. lat., March 8 to April 6, 1954.*

Element	Longitude (° W.)						
	130	120	110	100	90	80	70
Amplitude (ft.)	104	188	199	194	130	168	199
Phase angle (days)	5.1	0.0	0.5	1.1	2.6	3.8	4.5
R	.27	.54	.60	.50	.39	.48	.47

It is evident that a periodicity of appreciable proportions was manifest during this 30-day interval even by rigid statistical standards. The closest approximation to simple sinusoidal oscillation was at 40° N., 110° W., where a 6-day cosine wave with amplitude of about 200 ft. accounts for more than ⅓ of the variability which occurred there between March 8 and April 6. A like test of sea level pressures at Salt Lake City showed an amplitude of 8.2 mb. with a correlation of 0.72 for a similarly fitted 6-day wave. It is quite likely that the general level of the correlations could be raised by omitting the last 6 days.

A further test of the cycle lies in the progression of the phase angle with longitude. If the perturbations travel downstream, a regular or at least consistent variation of phase with latitude should be evident. Table 1 shows such a progression. For instance, the maximum (or minimum) of the periodic component of the height changes occurred 1.1 days (1.1−0.0) later at 100° W. than it did at 120° W. It took 2.7 days (3.8−1.1) to travel from 100° W. to 80° W. Thus, although the speed of eastward motion is not constant, there is a real progression eastward in the desired physical sense.

In relation to previous periodicities reported, several statements can be made:

1. This was a fairly strong, well-marked recurrence, although the effect did not seem to persist as long as the more prominent previous recurrences [8, 9, 12].
2. It reached its maximum of amplitude and correlation roughly in the area of strong cyclonic curvature aloft if one uses figure 3b as indicative of mean conditions. This agrees with the association suggested by Namias [12].
3. No relationship has yet been established between mean circulation and the time between recurrences. This relationship can possibly be established by the further accumulation and processing of data.
4. Reports in the past have shown that cloud seeding is generally practiced when the meteorological situation is favorable for rain. If pulses arrive periodically from the Pacific, then seeding is usually timed to meet these events. A critical test of the effects of cloud seeding on the production or control of periodicities is quite difficult under these circumstances.

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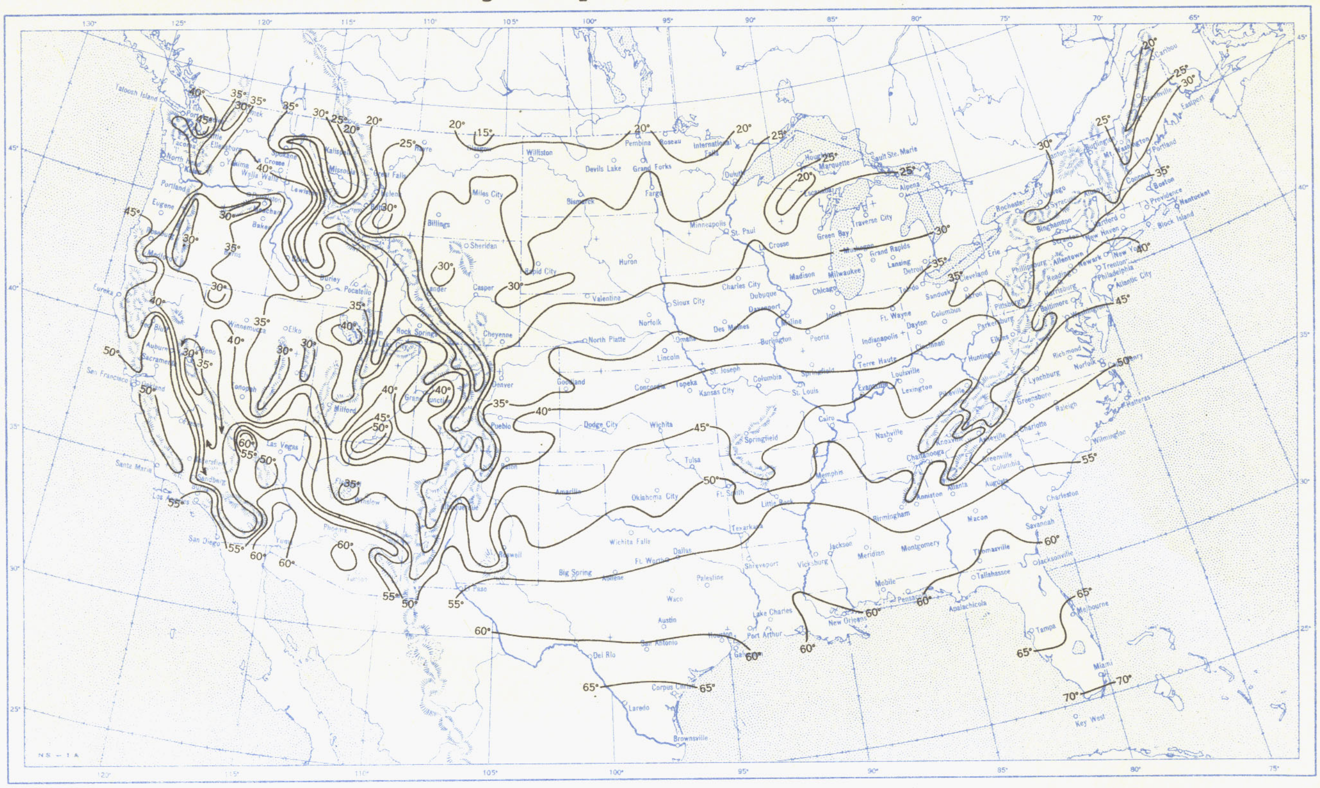
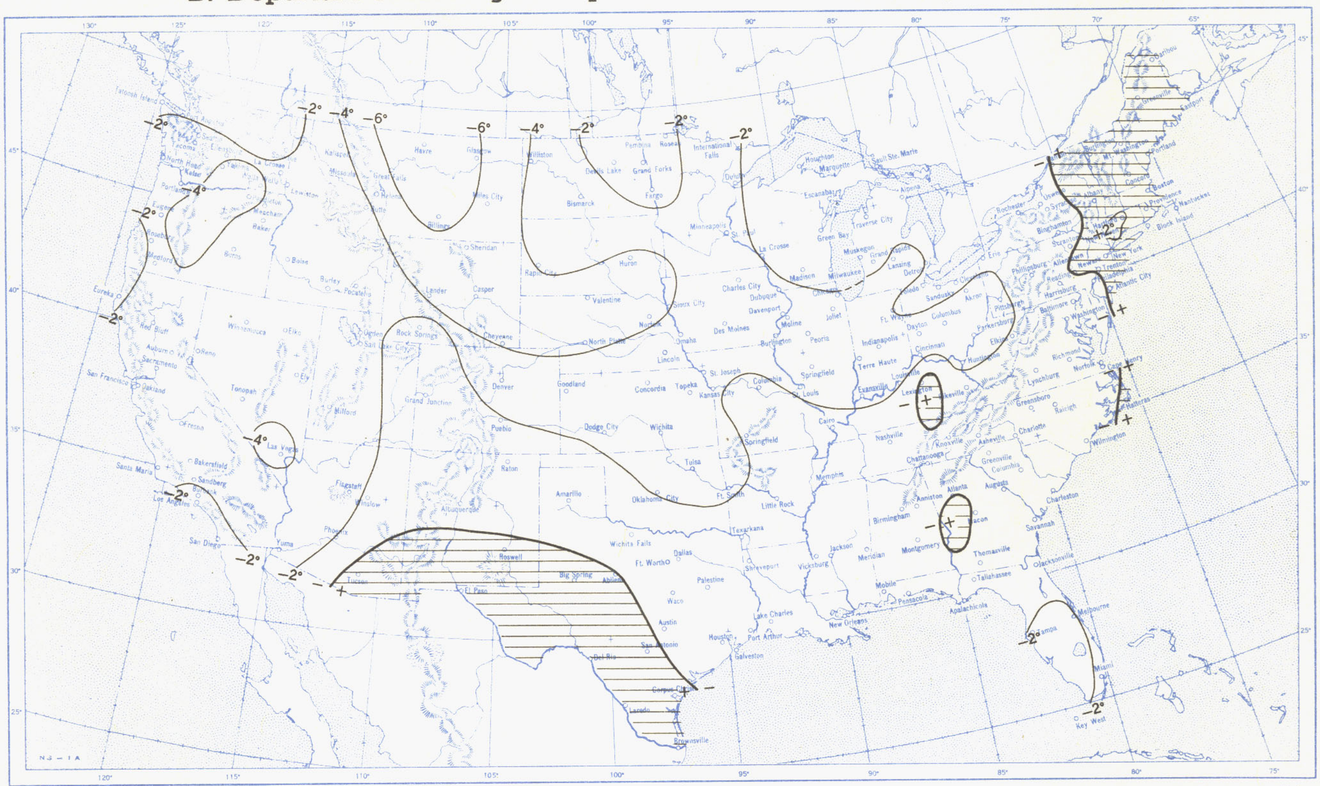
13. V. Conrad and L. W. Pollak, *Methods in Climatology*, 2d edition, Harvard University Press, 1950, pp. 119–154.

Chart I. A. Average Temperature (°F.) at Surface, March 1954.



B. Departure of Average Temperature from Normal (°F.), March 1954.

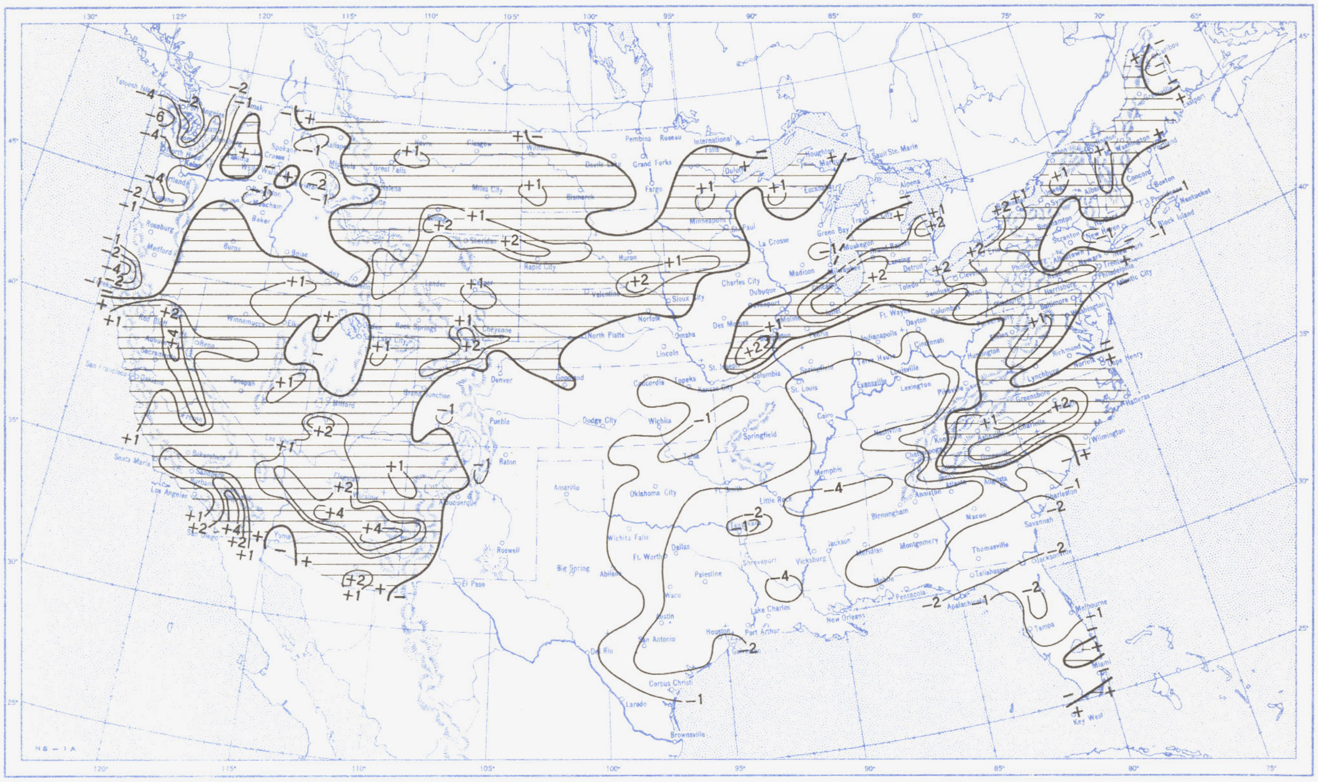


A. Based on reports from 800 Weather Bureau and cooperative stations. The monthly average is half the sum of the monthly average maximum and monthly average minimum, which are the average of the daily maxima and daily minima, respectively.
B. Normal average monthly temperatures are computed for Weather Bureau stations having at least 10 years of record.

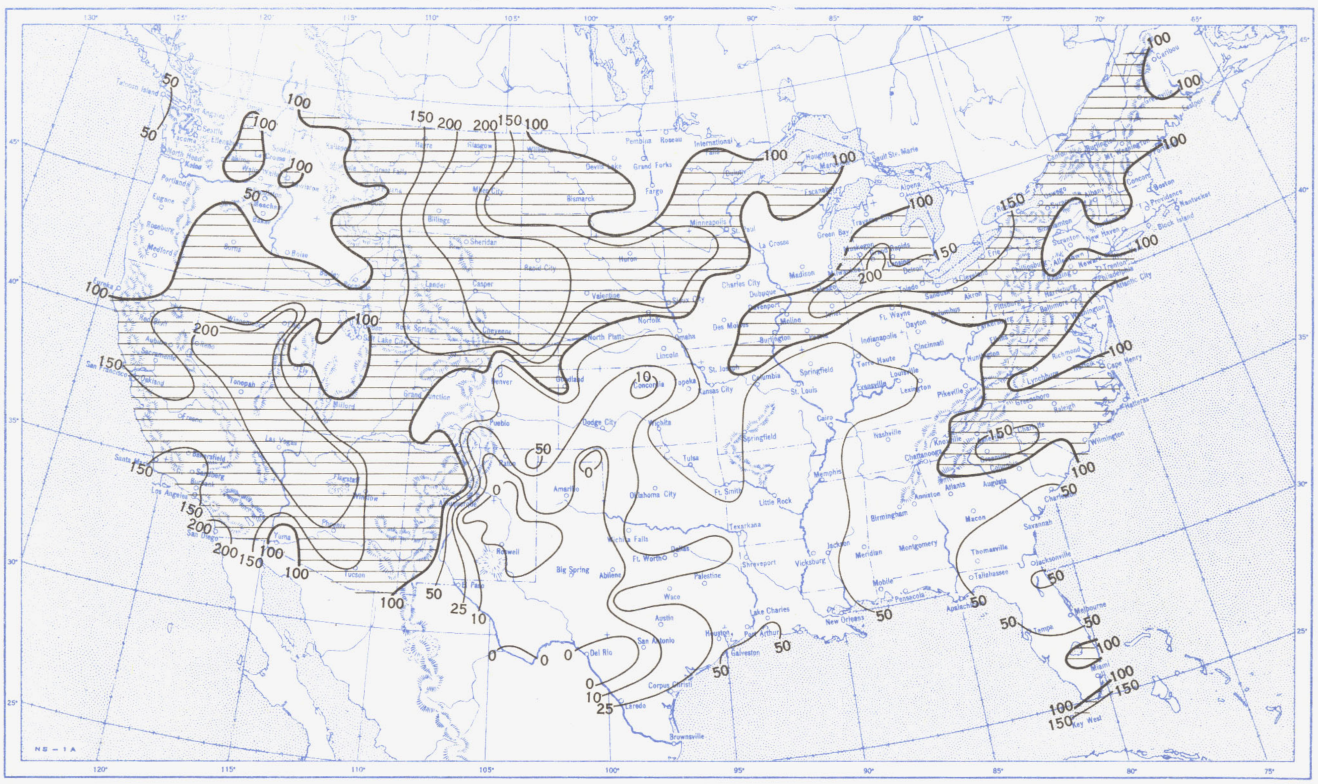
Chart II. Total Precipitation (Inches), March 1954.

Based on daily precipitation records at 800 Weather Bureau and cooperative stations.

Chart III. A. Departure of Precipitation from Normal (Inches), March 1954.



B. Percentage of Normal Precipitation, March 1954.

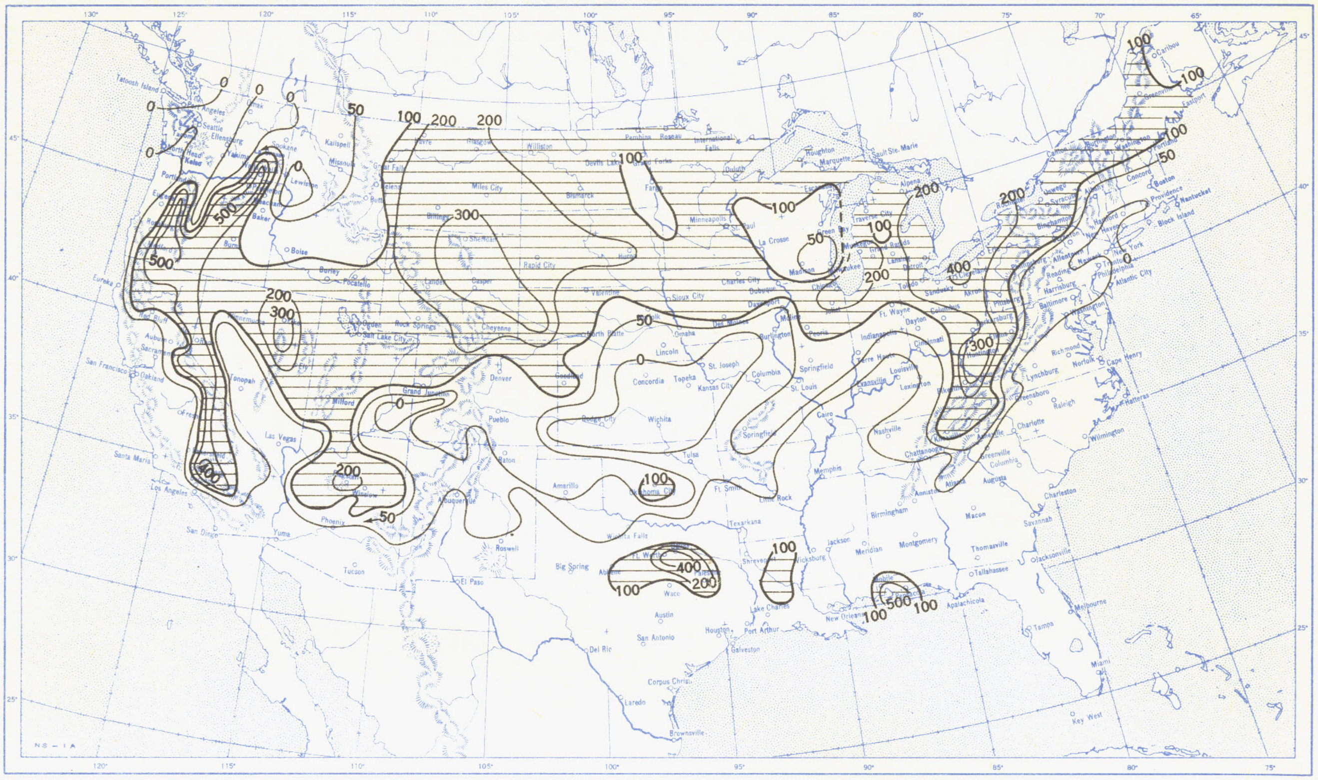


Normal monthly precipitation amounts are computed for stations having at least 10 years of record.

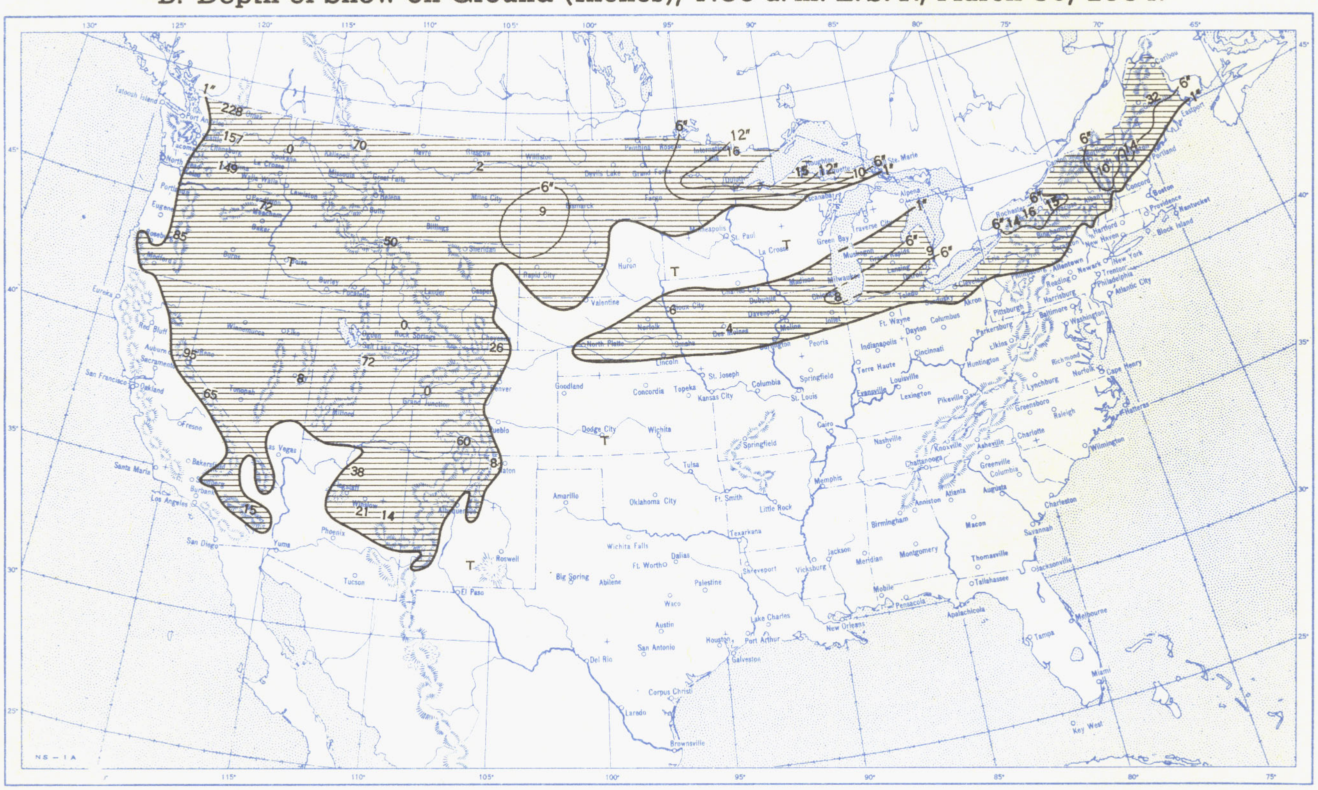
Chart IV. Total Snowfall (Inches), March 1954.

This is the total of unmelted snowfall recorded during the month at Weather Bureau and cooperative stations. This chart and Chart V are published only for the months of November through April although of course there is some snow at higher elevations, particularly in the far West, earlier and later in the year.

Chart V. A. Percentage of Normal Snowfall, March 1954.

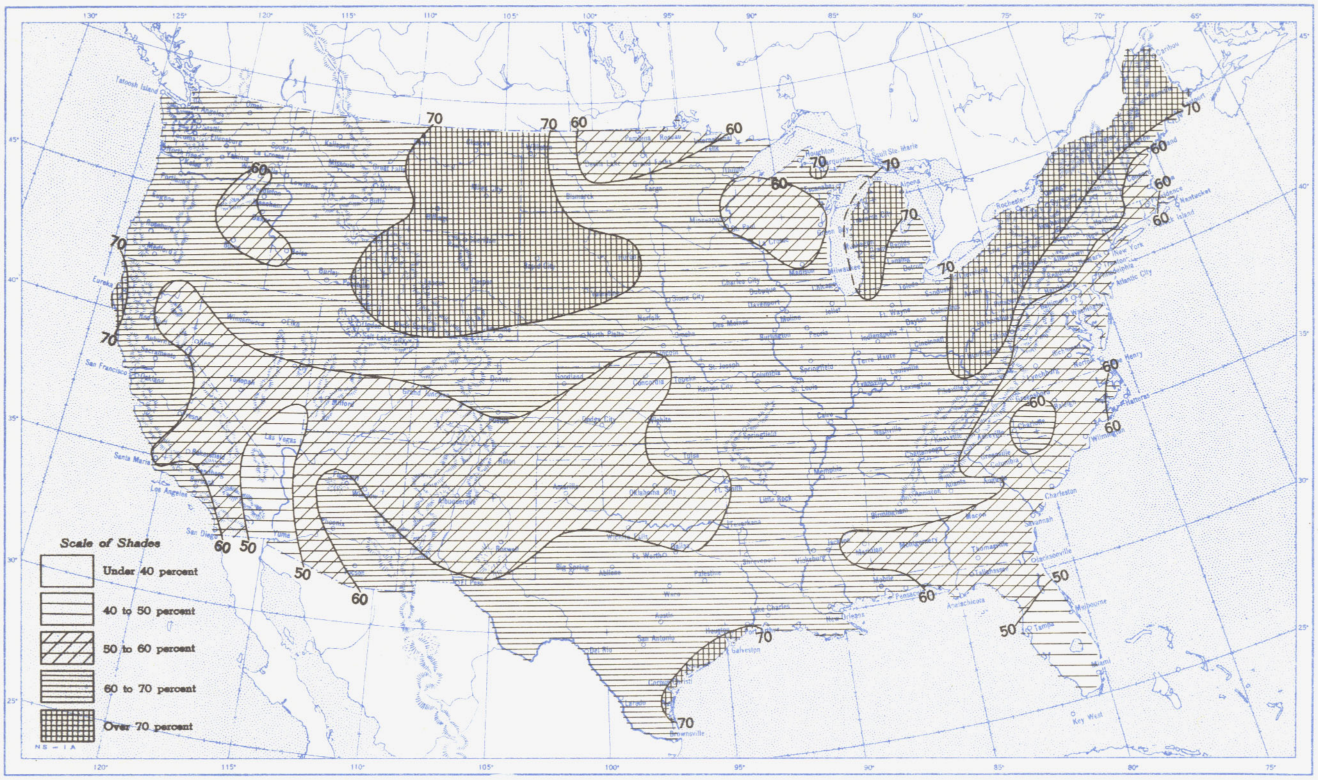


B. Depth of Snow on Ground (Inches), 7:30 a. m. E. S. T., March 30, 1954.

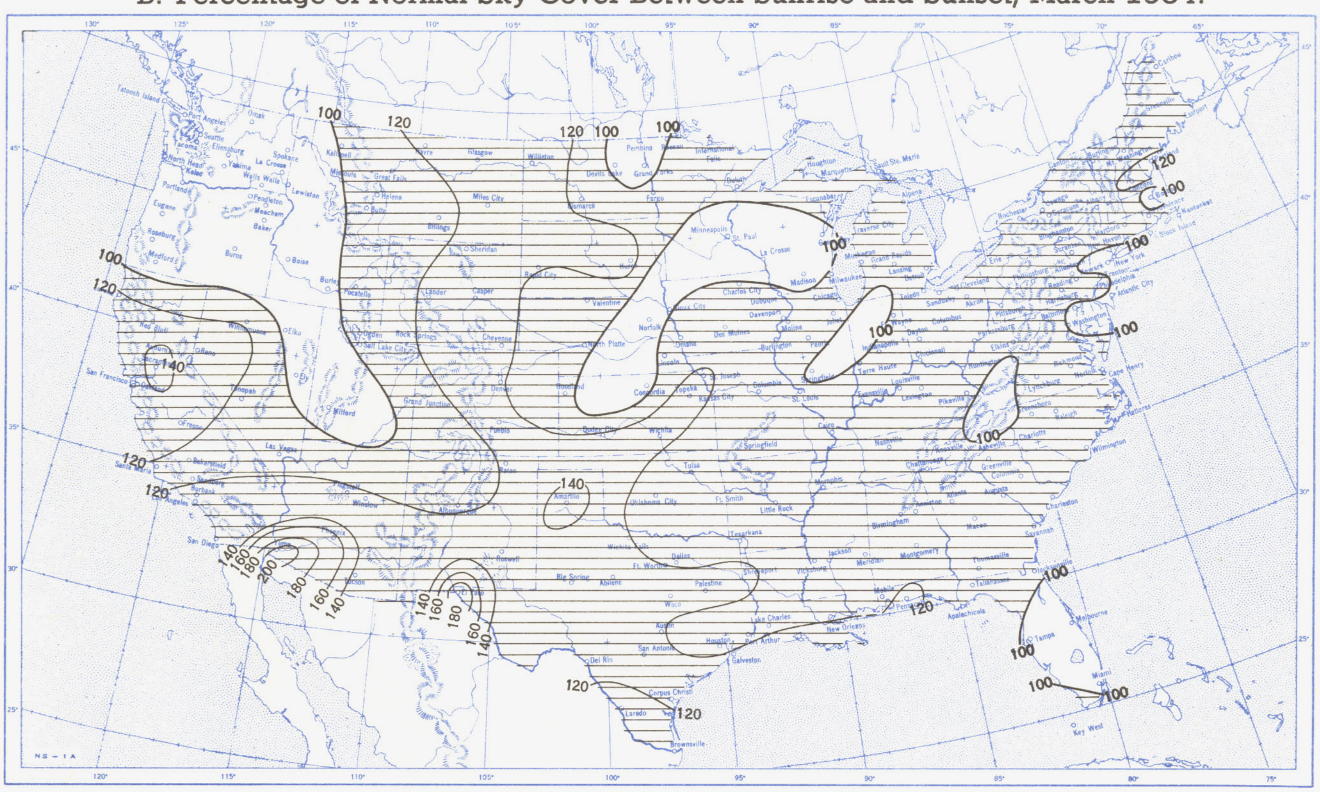


A. Amount of normal monthly snowfall is computed for Weather Bureau stations having at least 10 years of record.
B. Shows depth currently on ground at 7:30 a. m. E. S. T., of the Tuesday nearest the end of the month. It is based on reports from Weather Bureau and cooperative stations. Dashed line shows greatest southern extent of snowcover during month.

Chart VI. A. Percentage of Sky Cover Between Sunrise and Sunset, March 1954.

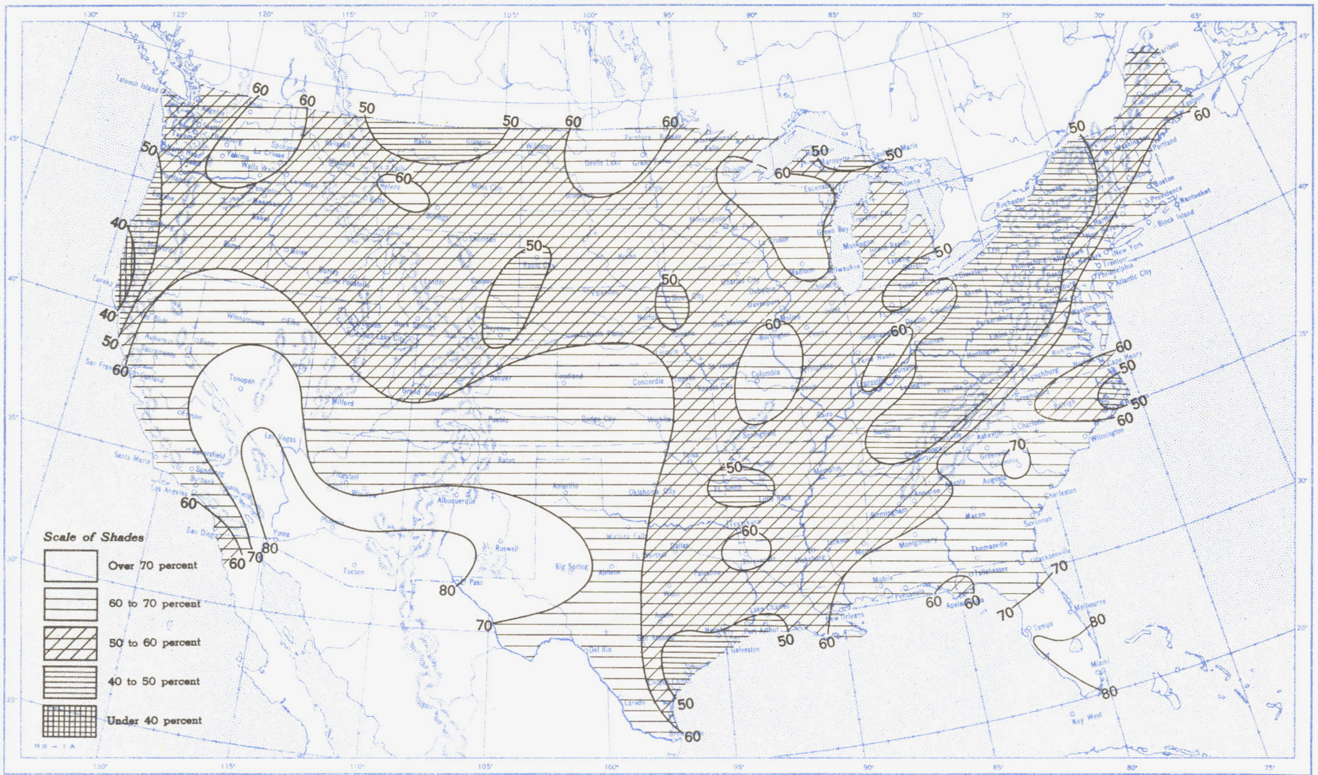


B. Percentage of Normal Sky Cover Between Sunrise and Sunset, March 1954.

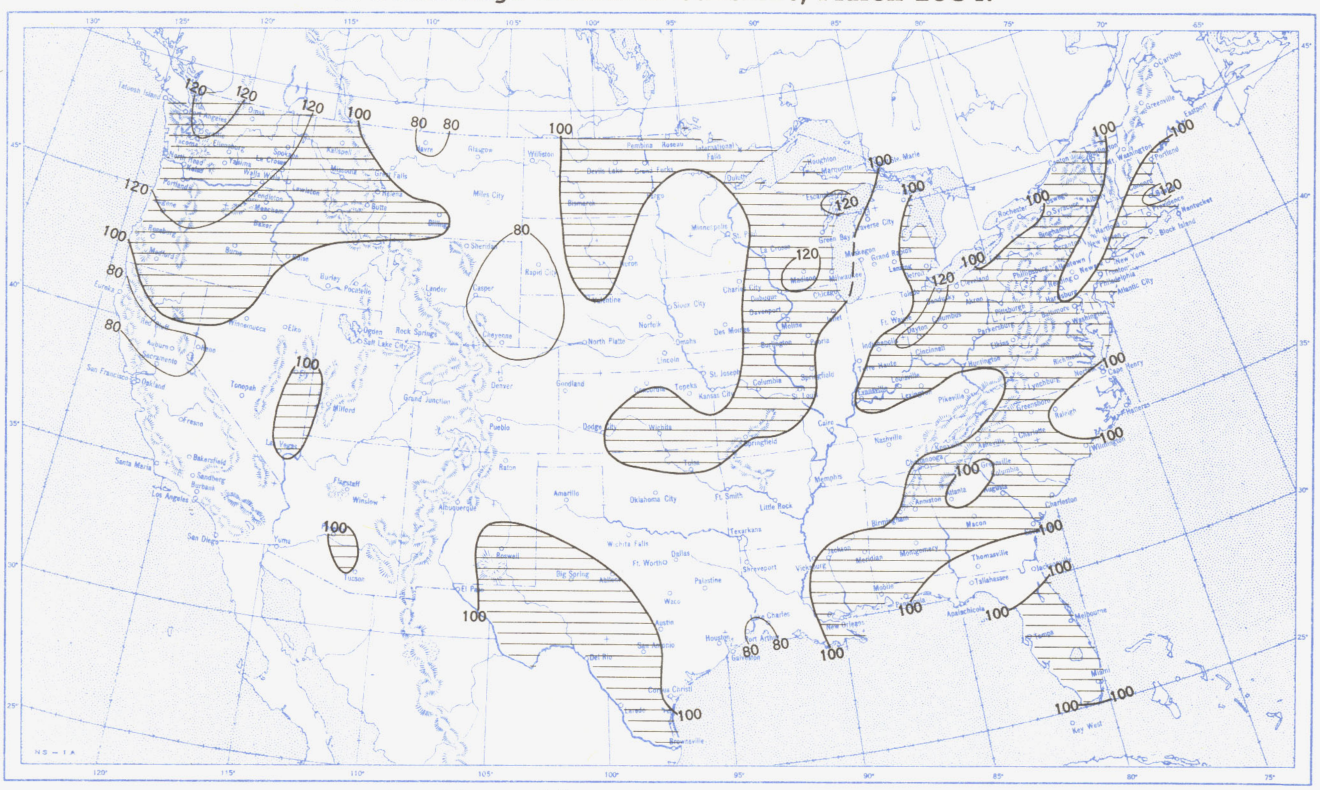


A. In addition to cloudiness, sky cover includes obscuration of the sky by fog, smoke, snow, etc. Chart based on visual observations made hourly at Weather Bureau stations and averaged over the month. B. Computations of normal amount of sky cover are made for stations having at least 10 years of record.

Chart VII. A. Percentage of Possible Sunshine, March 1954.



B. Percentage of Normal Sunshine, March 1954.



A. Computed from total number of hours of observed sunshine in relation to total number of possible hours of sunshine during month. B. Normals are computed for stations having at least 10 years of record.

Chart VIII. Average Daily Values of Solar Radiation, Direct + Diffuse, March 1954. Inset: Percentage of Normal Average Daily Solar Radiation, March 1954.

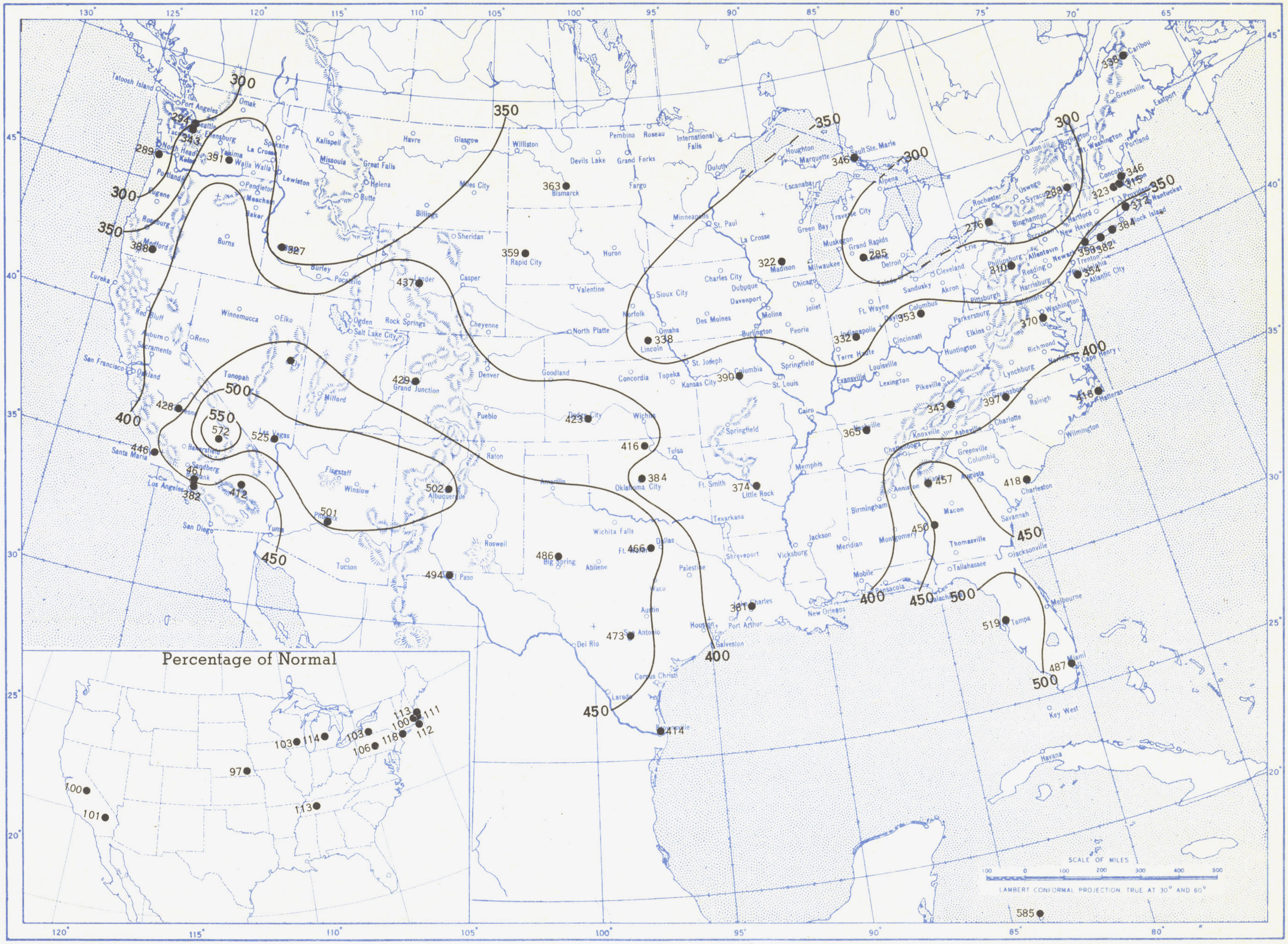
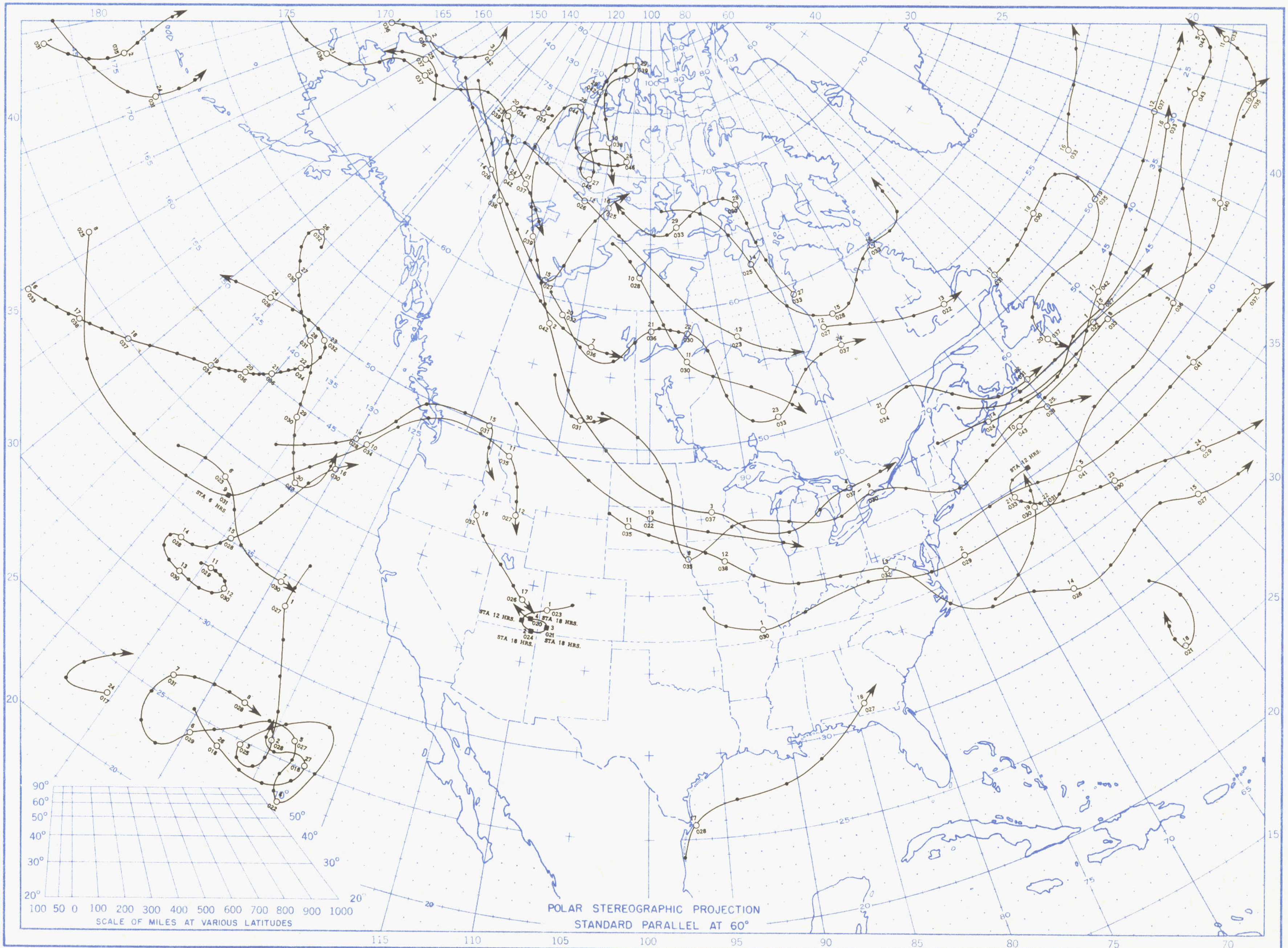


Chart shows mean daily solar radiation, direct + diffuse, received on a horizontal surface in langleys (1 langley = 1 gm. cal. cm. $^{-2}$). Basic data for isolines are shown on chart. Further estimates are obtained from supplementary data for which limits of accuracy are wider than for those data shown. Normals are computed for stations having at least 9 years of record.

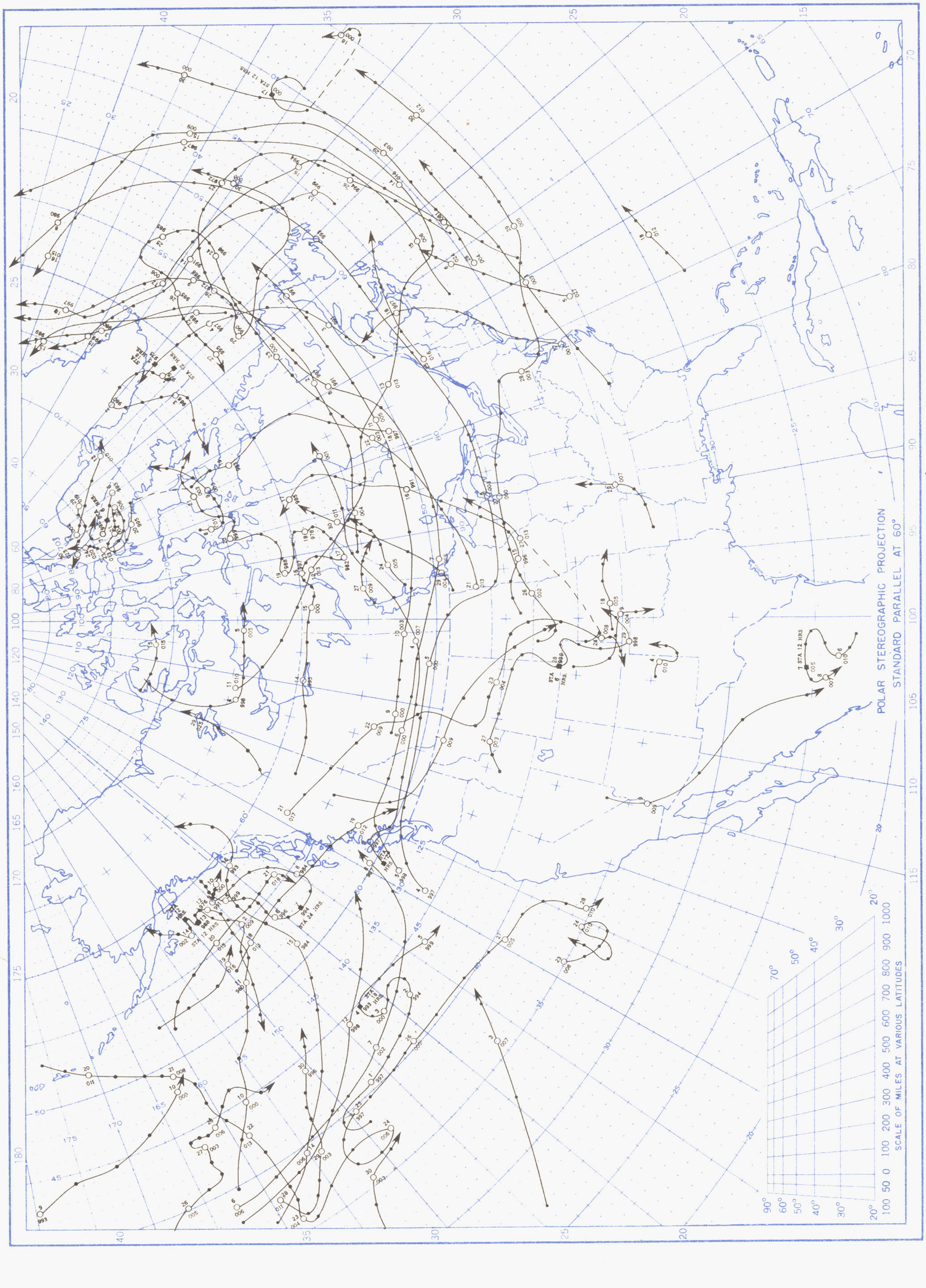
Chart IX. Tracks of Centers of Anticyclones at Sea Level, ~~March~~ APRIL 1954.



Circle indicates position of center at 7:30 a. m. E. S. T. Figure above circle indicates date, figure below, pressure to nearest millibar. Dots indicate intervening 6-hourly positions. Squares indicate position of stationary center for period shown. Dashed line in track indicates reformation at new position. Only those centers which could be identified for 24 hours or more are included.

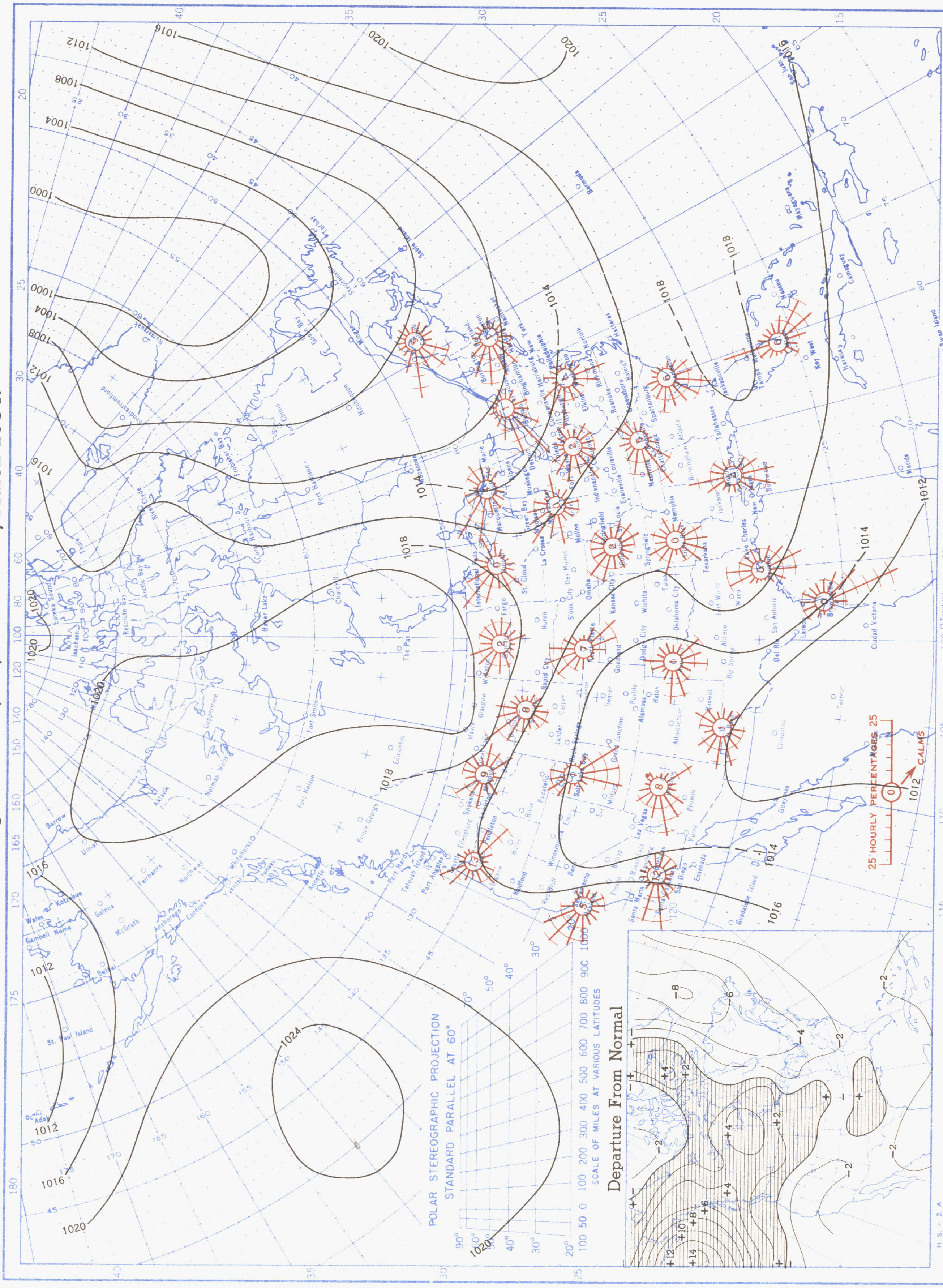
(See Apr 1954 folder)

Chart X. Tracks of Centers of Cyclones at Sea Level, ~~March~~ APRIL 1954.



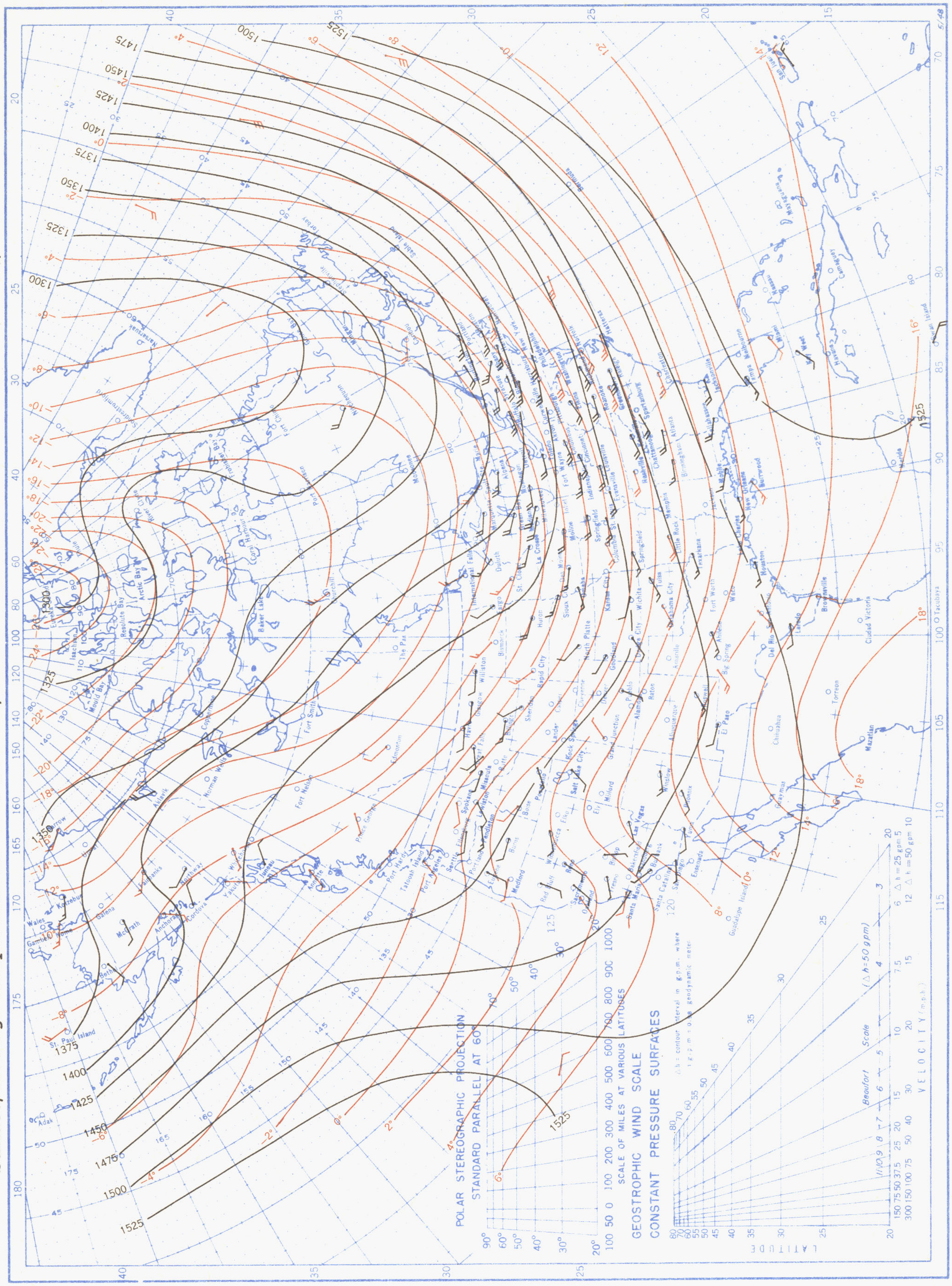
Circle indicates position of center at 7:30 a. m. E. S. T. See Chart IX for explanation of symbols.

Chart XI. Average Sea Level Pressure (mb.) and Surface Windroses, March 1954. Inset: Departure of Average Pressure (mb.) from Normal, March 1954.



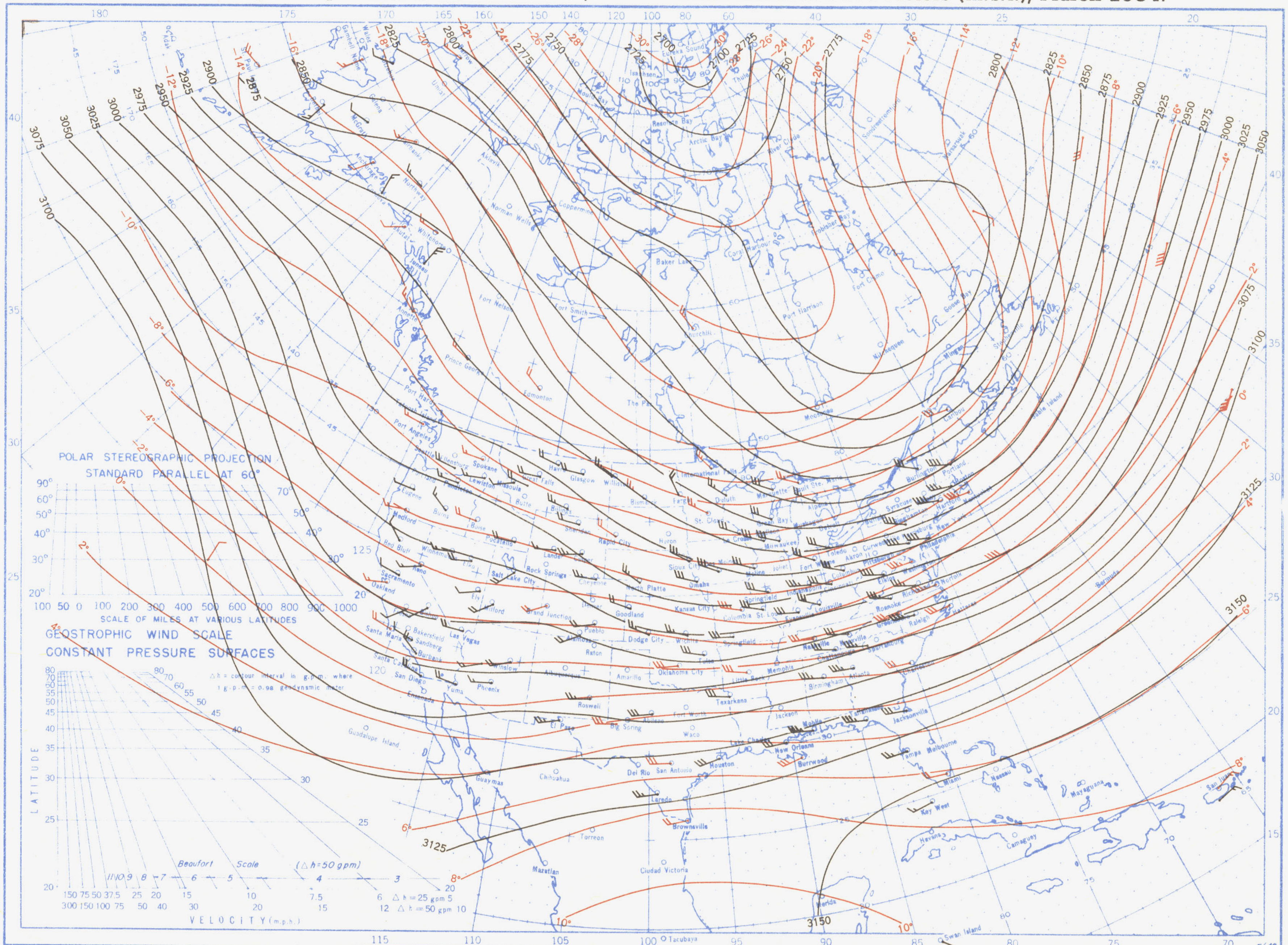
Average sea level pressures are obtained from the averages of the 7:30 a. m. and 7:30 p. m. E. S. T. readings. Windroses show percentage of time wind blew from 16 compass points or was calm during the month. Pressure normals are computed for stations having at least 10 years of record and for 10° intersections in a diamond grid based on readings from the Historical Weather Maps (1899-1939) for the 20 years of most complete data coverage prior to 1940.

Chart XII. Average Dynamic Height in Geopotential Meters (1 g.p.m. = 0.98 dynamic meters) of the 850-mb. Pressure Surface, Average Temperature in °C. at 850 mb., and Resultant Winds at 1500 Meters (m.s.l.), March 1954.



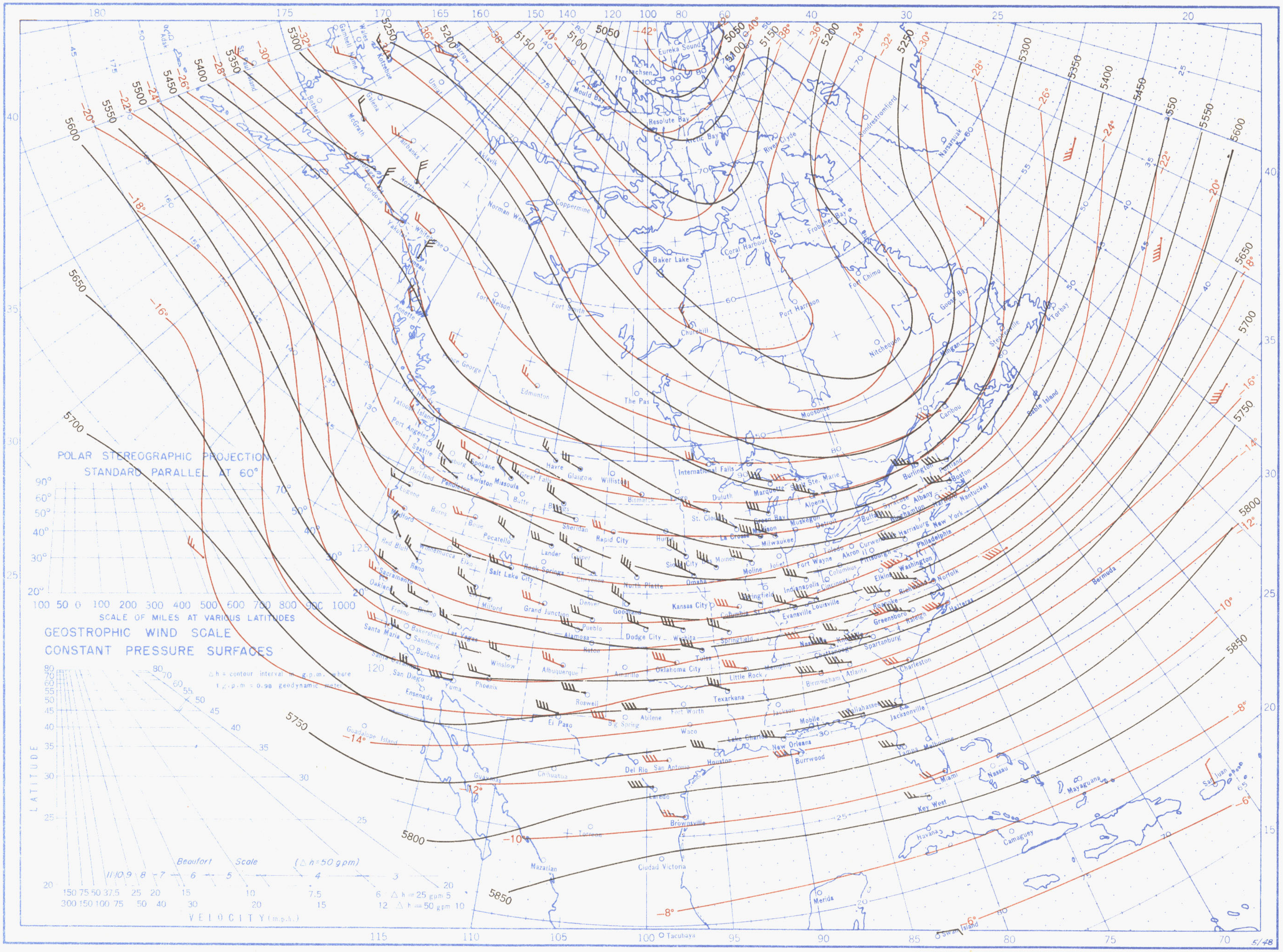
Contour lines and isotherms based on radiosonde observations at 0300 G. M. T. Winds shown in black are based on pilot balloon observations at 2100 G. M. T.; those shown in red are based on rawins taken at 0300 G. M. T. Wind barbs indicate wind speed on the Beaufort scale.

Chart XIII. Average Dynamic Height in Geopotential Meters (1 g.p.m.. = 0.98 dynamic meters) of the 700-mb. Pressure Surface, Average Temperature in °C. at 700 mb., and Resultant Winds at 3000 Meters (m.s.l.), March 1954.



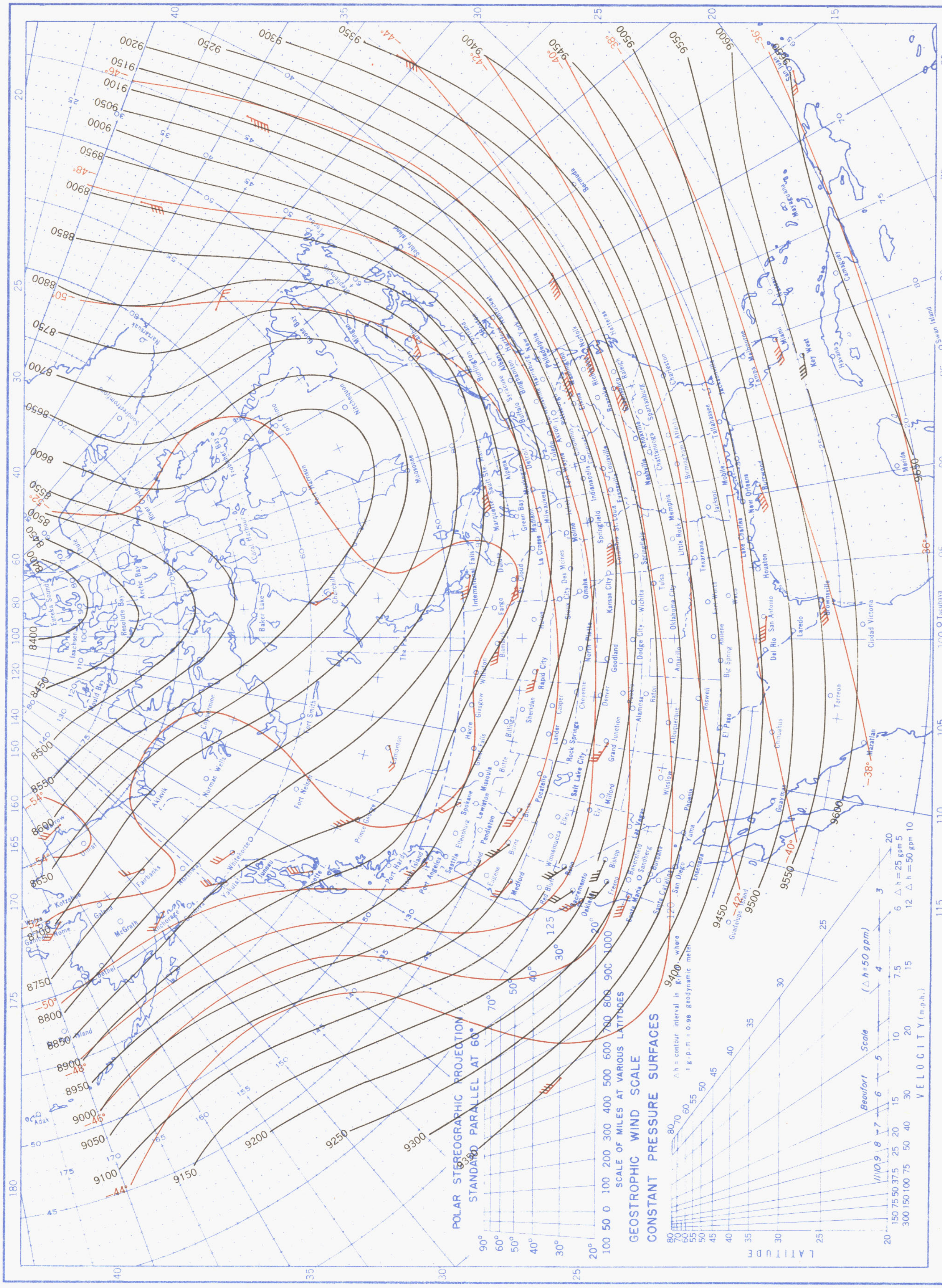
Contour lines and isotherms based on radiosonde observations at 0300 G. M. T. Winds shown in black are based on pilot balloon observations at 2100 G. M. T.; those shown in red are based on rawins taken at 0300 G. M. T. Wind barbs indicate wind speed on the Beaufort scale.

Chart XIV. Average Dynamic Height in Geopotential Meters (1 g.p.m. = 0.98 dynamic meters) of the 500-mb. Pressure Surface, Average Temperature in °C. at 500 mb., and Resultant Winds at 5000 Meters (m.s.l.), March 1954.



Contour lines and isotherms based on radiosonde observations at 0300 G. M. T. Winds shown in black are based on pilot balloon observations at 2100 G. M. T.; those shown in red are based on rawins at 0300 G. M. T. Wind barbs indicate wind speed on the Beaufort scale.

Chart XV. Average Dynamic Height in Geopotential Meters (1 g.p.m. = 0.98 dynamic meters) of the 300-mb. Pressure Surface, Average Temperature in °C. at 300 mb., and Resultant Winds at 10,000 Meters (m.s.l.), March 1954.



Contour lines and isotherms based on radiosonde observations at 0300 G. M. T. Winds shown in black are based on pilot balloon observations at 2100 G. M. T.; those shown in red are based on rawins at 0300 G. M. T. Wind barbs indicate wind speed on the Beaufort scale.